Topological index-based filtering to identify suitable nanocarriers for Amoxicillin: a graph theoretical approach

W. T. L. D. Thathsarani[1], K. K. W. H. Erandi[1], U. P. Liyanage[1], S. S. N. Perera[1], P. Paranamana[2]

[1]*Centre for Mathematical Modeling, Department of Mathematics, Faculty of Science, University of Colombo, Sri Lanka*
[2]*Saint Mary's College, Norte Dame, Indiana, USA*

Dendrimers are well-defined, hyperbranched nanocarriers with significant potential in antibiotic delivery systems. This study applies graph-theoretical analysis to identify topological indices of four dendrimer classes Poly (amidoamine) (PAMAM), Poly (propylene imine) (PPI), Polyester, and Hybrid, when loaded with Amoxicillin. Two drug-loading strategies are considered; covalent surface attachment and internal encapsulation. Each dendrimer is modelled across three generations: Generation 1 (G1), Generation 2 (G2), and Generation 3 (G3), with molecular structures represented as graphs. Each successive generation introduces a new layer of branching units extending from the terminal groups of the previous generation. The study focuses on minimizing the filtering process required during experimental screening, to reduce the cost and complexity of drug design. To predict the dendrimer-based nanocarriers more efficiently, these structures are quantitatively assessed using topological indices, including the Wiener, Zagreb, Schultz, Randić, Harary, Balaban, and Kappa indices. A generation-wise comparison shows that increasing dendrimer generations enhances topological indices such as Wiener and Schultz, indicating improved branching and drug-holding capacity. However, higher generations may reduce flexibility and compromise biocompatibility. Among the structures tested, G2 emerges as the optimal configuration for the PAMAM, PPI, and Polyester dendrimers, with a medium-chain length preferred for Polyester. For Hybrid dendrimers, the most effective system is a combination of PAMAM-G2 with a medium-chain Polyester, offering a balance of encapsulation volume and structural stability. The results indicate that PPI-G2 with covalently bonded Amoxicillin shows high stability and controlled release, supported by strong Schultz and Randić index values. In the case of the Hybrid dendrimer with encapsulated Amoxicillin, the structure displays excellent topological balance, with high Harary and Wiener indices indicating compactness and diffusion, and moderate Kappa indices reflecting flexibility. These findings confirm the utility of topological indices as predictive tools for evaluating nanocarrier structures and highlight the suitability of specific dendrimer architectures for efficient antibiotic delivery

Keywords: *Topological indices, Dendrimers, Amoxicillin delivery, Chemical graph theory, Nanocarriers*